

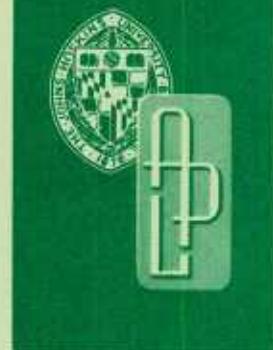
REPORT DOCUMENTATION PAGE

1. REPORT NUMBER APL/JHU TG 1306	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) COMPUTERIZED AIR BATTLE USING INTERACTIVE GRAPHICS TECHNIQUES		5. TYPE OF REPORT & PERIOD COVERED Technical Memorandum
		6. PERFORMING ORG. REPORT NUMBER TG 1306
7. AUTHOR(s) T. P. Modelska, R. A. Freeman, and J. Wang		B. CONTRACT OR GRANT NUMBER(s) N00017-72-C-4401
9. PERFORMING ORGANIZATION NAME & ADDRESS The Johns Hopkins University Applied Physics Laboratory Johns Hopkins Road Laurel, MD 20810		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Z02A
11. CONTROLLING OFFICE NAME & ADDRESS Chief of Naval Operations, OP-96 Department of the Navy Washington, DC 20350		12. REPORT DATE April 1977
		13. NUMBER OF PAGES 51
14. MONITORING AGENCY NAME & ADDRESS Naval Plant Representative Office Johns Hopkins Road Laurel, MD 20810		15. SECURITY CLASS. (of this report) Unclassified
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Interactive Graphics Man-Machine Interactions Air Battle Naval Warfare		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A procedure has been developed that is a computerized outer-air battle using interactive graphics techniques. With an interactive graphics terminal as the interface between the analyst and a computer program, the analyst can be placed "in the loop" and thus act on intelligence generated throughout the simulation of a military operation. Because the decision logic is supplied by the analyst, not fixed in the program, the simulation complexity, model size, and model development time are considerably reduced.		
The model is a time-step, two-dimensional dynamic simulation written in PL/I for an IBM 360/370 series computer with a Tektronics 4015 graphics display console and a hard-copy unit.		

AD A 0541
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APL/JHU
TG 1306
APRIL 1977
Copy No. 11

AD A 045471



Technical Memorandum

COMPUTERIZED AIR BATTLE USING INTERACTIVE GRAPHICS TECHNIQUES

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ABSTRACT

A procedure has been developed that is a computerized outer-air battle using interactive graphics techniques. With an interactive graphics terminal as the interface between the analyst and a computer program, the analyst can be placed "in the loop" and thus act on intelligence generated throughout the simulation of a military operation. Because the decision logic is supplied by the analyst, not fixed in the program, the simulation complexity, model size, and model development time are considerably reduced.

The model is a time-step, two-dimensional dynamic simulation written in PL/I for an IBM 360/370 series computer with a Tektronics 4015 graphics display console and a hard-copy unit.

PREFACE

The procedure described is a computerized air battle analyzer* using interactive graphics techniques that allow the analyst the freedom to make decisions during the game and save time by using a computer graphics terminal for automatic plotting and computation. The interactive graphics approach enables the analyst to generate the kinematic routines, detection routines, etc., of a full computer simulation without spending long development times in trying to conceive of all the tactical decisions that must be represented and permitted to be altered by input selection.

For the hand games proponent, the computer-support graphics display is more precise than he will normally have from his hand plots, and he spends his time at decision points rather than at keeping books.

For report purposes, complete plots, summary tables, history of events, and geographic displays are readily available through the hard-copy device connected to the graphics console.

For analysis purposes, in addition to the hard-copy output, a chronological game history is available in the form of paper output.

*APL/JHU TG 421, "Air Battle Handbook," April 1963.

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1. INTRODUCTION

Recent developments in computer technology permit amalgamation of analytic, gaming, and computer simulation techniques to a degree not previously practicable. Using a modern, interactive graphics terminal as the interface between the analyst and a computer program, the analyst is placed "in the loop" and can act on intelligence generated throughout the simulation of a military operation. Because the decision logic is supplied by the analyst, not fixed in the program, the simulation complexity, model size, and model development time are considerably reduced.

The advantages of hand gaming (i.e., being able to examine various decision doctrines and to easily maintain interim results) are retained while the time of play is greatly decreased. The advantages of a fully computerized simulation (primarily, ability to represent an action in detail and compute at high speed) are retained while the principal disadvantage of the purely analytic technique (oversimplification of a complex problem) is reduced.

When the program is properly constructed, it can have interchangeable subroutines of varying detail, allowing either a precise simulation or an abstract algorithm to be used to represent a particular action.

This model (Fig. 1) is a time-step, two-dimensional, dynamic simulation written in PL/I for either an IBM 360 or 370 computer with a Tektronics 4015 large-screen graphics-display console and a hard-copy unit. A flexible disk memory is also available. This device allows the analyst to record the entire game (or games) directly from the console screen and then to play back all or part of it for demonstration or report purposes. Hard copies can be made during the playback. The model is interactive in that the analyst makes all of the controlling decisions throughout operation of the model. The model operates by presenting a series of displays on the graphics console. Decisions that control the operation of either the simulation or the operation of the individual units can be made by using the alphanumeric keyboard and the crosshairs of the graphics console.

The present model is designed to simulate an outer-air battle, with interactions ranging from detection through repeated attacks. Because this simulation is highly modular and different unit interaction packages can be developed easily as different needs arise, the model need not be limited to air battles. The

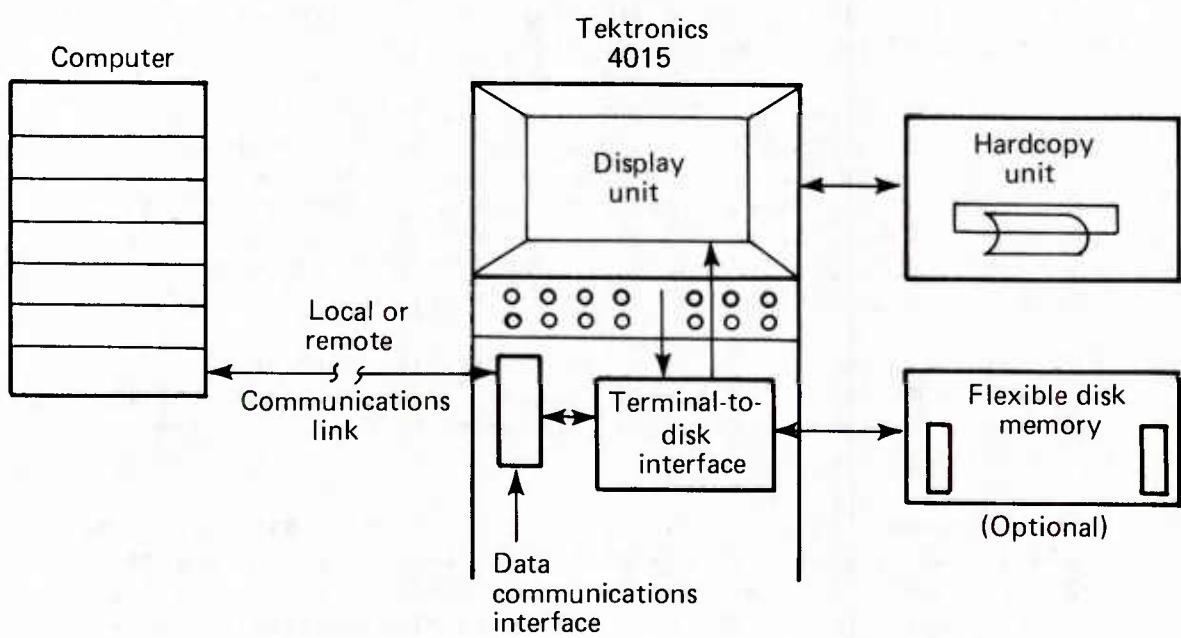


Fig. 1 Hardware Interface Diagram

game is played between Blue and Red forces. Blue forces are controlled by the analyst, whereas Red forces are controlled by input before the game is started.

The Blue units consist of a carrier (the launching platform for Blue aircraft and the game reference point) and various types of aircraft such as airborne early warning (AEW), combat air patrol (CAP), and interceptors. Aircraft detection and weapon characteristics are determined by input.

The Red aircraft are set up as raids, which may consist of one to many aircraft. Red tactics and detection characteristics are determined by input. In addition, each Red aircraft can be selected by input to be a communications jammer, a radar jammer, a reconnaissance aircraft, or a weapons carrier.

In summary, the following advantages and limitations arise out of the technique:

1. Advantages

- a. The analyst reacts to intelligence as it is generated during the game.
- b. The analyst supplies control logic, reducing size and complexity of model.
- c. Modifications are more easily accomplished because control logic is external.
- d. A variety of displays and hard-copy output are available throughout game.
- e. The analyst can vary logic from play-to-play for analysis or training purposes.

2. Limitations

- a. A player-participation game may require several hours to complete. Therefore the number of replications is limited.
- b. Because the game logic is supplied by the analyst, replications must be interpreted differently than for fully computerized simulations.

Currently, the model has provisions for five types of units with approximately 50 units of each type. Unit types 1 through 3

are designated Blue and type 5 is designated Red. The unit descriptors are:

- 1 = Reference point (carrier)
- 2 = VS/AEW aircraft
- 3 = Interceptor aircraft
- 4 = (not used)
- 5 = Air raids

2. PROGRAM OPERATION

All Blue units are controlled by the analyst. Inputs to the game determine the number of each type of unit and detection and weapon characteristics.

To start the game the analyst selects a scenario and geographic area and positions his units where he wants them. Then, he updates the units, based on the desired time-step. Courses and speeds of all Blue units can be changed by the analyst at any time. Blue aircraft can be sent to patrol areas or contacts at the discretion of the analyst.

Red bomber raids operate automatically, based on the selection of input tracks. By input, each aircraft is placed within a raid that consists of from one to many aircraft. Each aircraft is then selected to be a reconnaissance aircraft, a bomber, a radar jammer, or a communications jammer. After this, each raid is given two input points on its track. These points can be either common or distinct for each raid (see Fig. 2). When the game reaches the input launch time (TMAX2), all raids proceed to their first point at input speeds. Each raid has its own speed along the tracks; thus, arrival can be selected as staggered or common. Upon arrival at the first point(s) the raid(s) immediately proceed to their second point. After arriving at the second point(s) each raid closes on the carrier (game reference point) at an input speed (except for reconnaissance aircraft, which remain at their second point and maintain surveillance). When the carrier position has been reached, or the aircraft have fired their missiles, it is assumed their mission has been completed.

The geographic displays were generated using a Mercator projection (1:26 000 000 or 1 in. = 273.3 nmi) for the appropriate area and scaled to fit the display window of the Tektronix 4015 console (see Fig. 3). The analyst uses the Mercator projection to select a starting location for the carrier and then converts the location to x-y coordinates. The coordinates are then input to the game and the positions of all other units are input as range and bearing from that point.

At TMAX2 (input) Red raids are launched from airfields at a speed of VT1.

After each raid arrives at its first point (PT1) it immediately proceeds to its next point at speed VT2.

After arriving at PT2 each raid closes on the carrier at an input speed. When it reaches RTAC it releases its ASM's.

Reconnaissance aircraft will remain at PT2 and maintain surveillance.

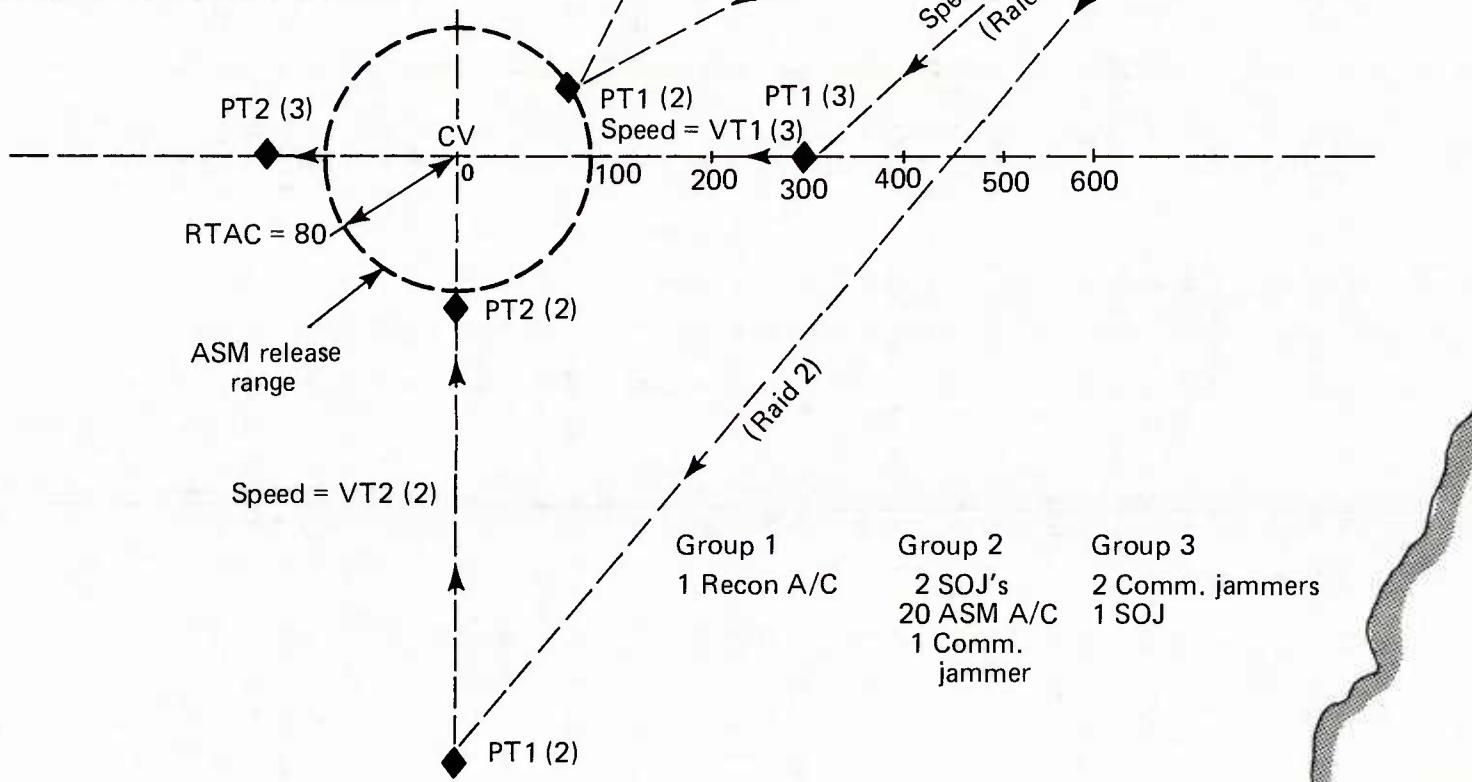


Fig. 2 Sample Red Air Raid Tracks

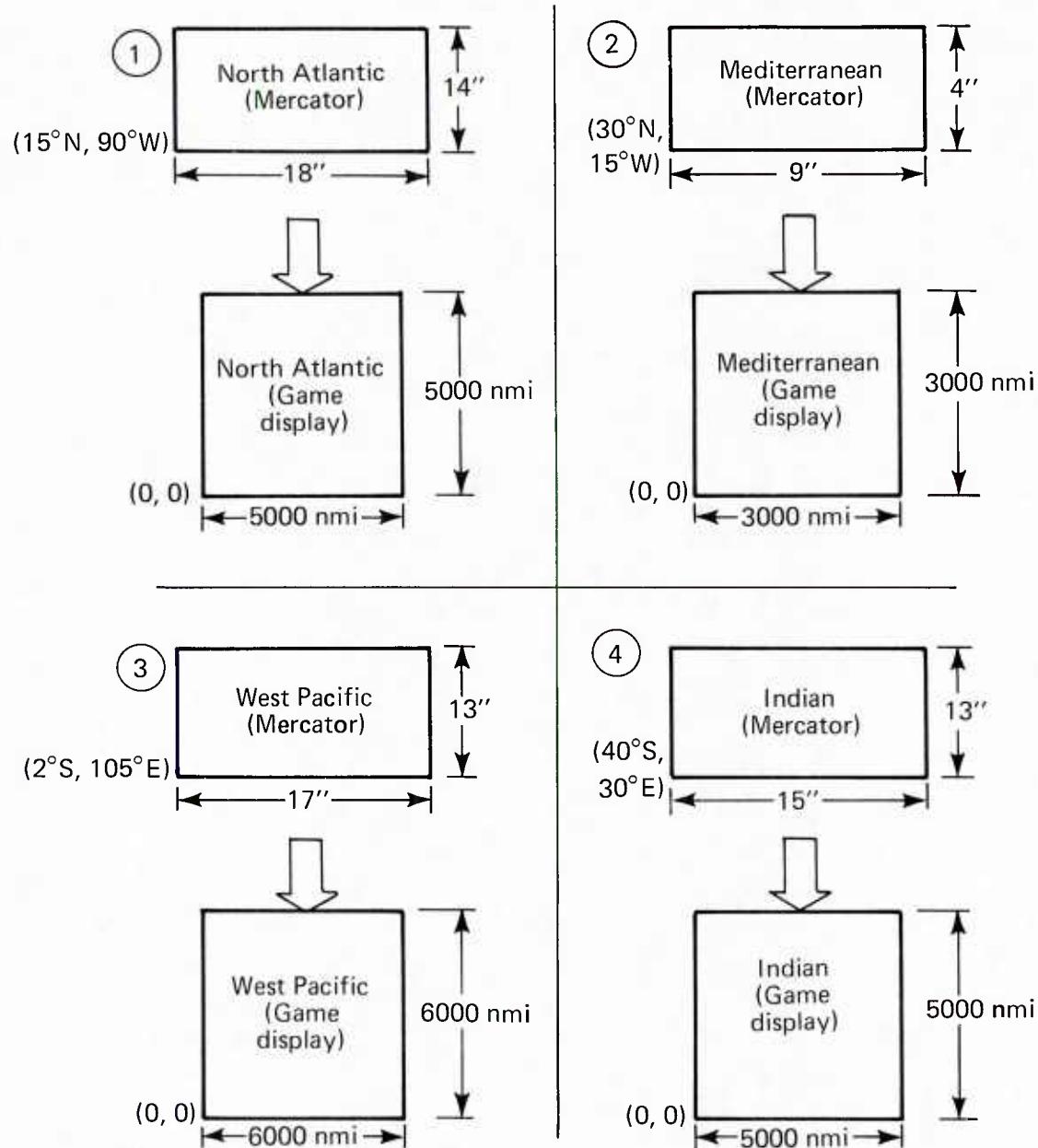


Fig. 3 Manner of Presenting Geographic Displays, Using a Mercator Projection Scaled to Fit the Display Window of the Tektronix 4015 Console

3. GRAPHICS DISPLAYS

The graphics displays were designed to give the analyst the necessary information to make informed decisions concerning the strategies of the Blue units.

GENERAL

Scales are in nautical miles (nmi).

Times are in hours and 100th of hours.

Courses and bearings are in degrees measured clockwise from north.

Speed is in knots (kt).

Positions are in nmi.

UNIT DESIGNATIONS

CV or 1 = Carrier

V or 2 = VS/AEW aircraft

F or 3 = Interceptor aircraft

B or 5 = Red bomber raid

M or 5 = Red communications jammer

GEOGRAPHIC DISPLAY

The geographic display serves two functions. As its name implies it is a pictorial presentation of the geographical location of the task force. This display is available for simulations of the Atlantic, Pacific, Indian, and Mediterranean areas. However, simulations must be conducted for each area individually. The display also enables the user to assign the desired task force track for the particular scenario and to locate the Blue airfields.

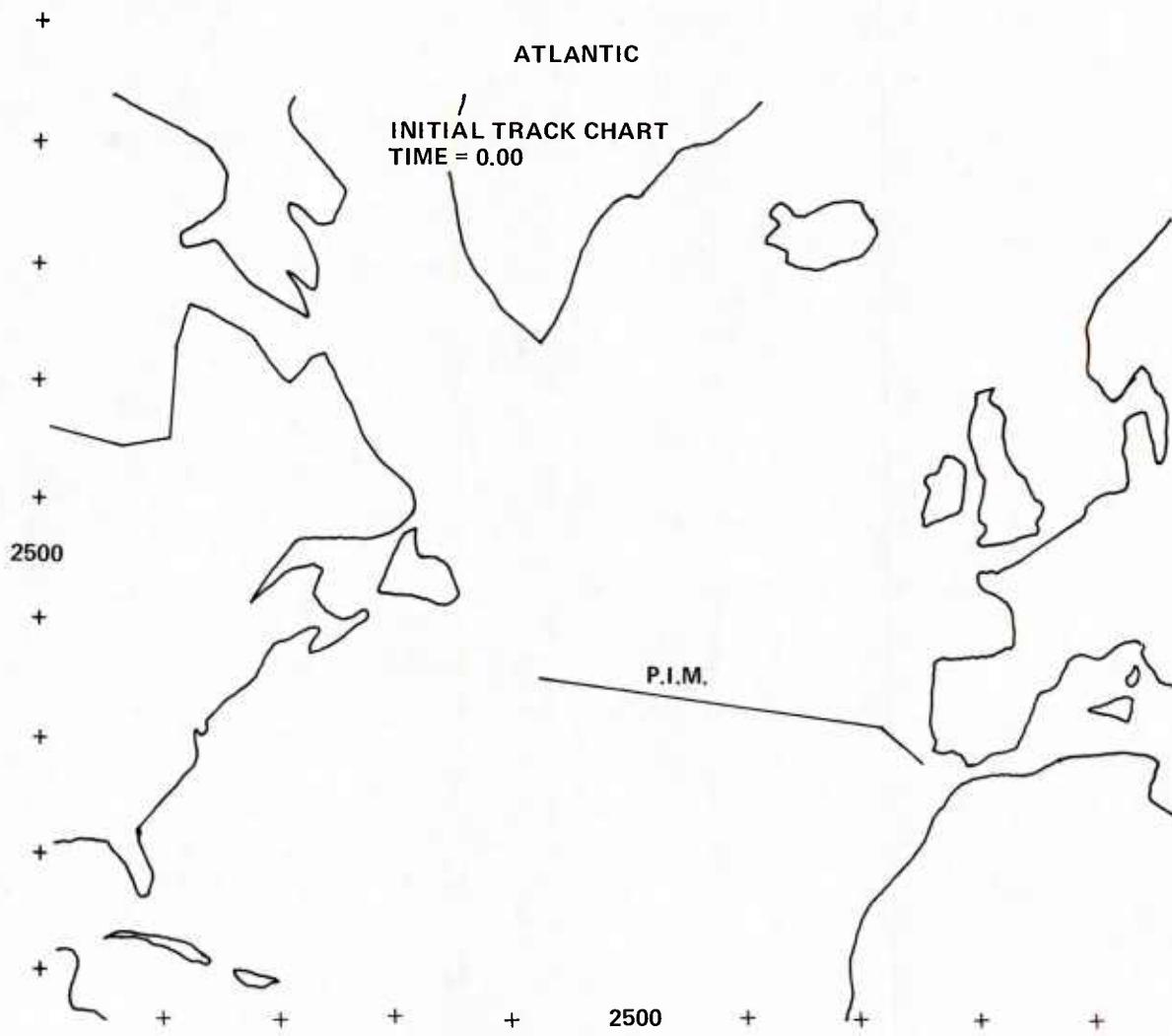


Fig. 4 An Actual Geographic Display

STATUS DISPLAY

The status display presents updated information about all Blue units. It consists of the current game time, range and bearing from the carrier, unit position, course and speed, range to contact, estimated time of arrival, and mission for each Blue unit in the game.

UNIT STATUS

CURRENT TIME IN HOURS = 0.50

CARRIER

R = 0 BRG = 0 X = 2119.4 Y = 1967.9 CRS = 90 SPD = 1
RANGE TO CONTACT = 0999.0 ETA = 999.0

VS 1

R = 292.2 BRG = 13 X = 2186.9 Y = 2152.2 CRS = 13 SPD = 0
RANGE TO CONTACT = 0.0 ETA = 0.0

AREA SEARCH

VS 2

R = 277.5 BRG = 50 X = 2332.5 Y = 2045.7 CRS = 90 SPD = 1
RANGE TO CONTACT = 0.0 ETA = 0.0

MOVING STATION

VS 3

R = 263.8 BRG = 89 X = 2383.8 Y = 1873.7 CRS = 90 SPD = 1
RANGE TO CONTACT = 0.0 ETA = 0.0

MOVING STATION

VS 4

R = 260.0 BRG = 123 X = 2336.5 Y = 1724.8 CRS = 90 SPD = 1
RANGE TO CONTACT = 0.0 ETA = 0.0

MOVING STATION

VS 5

R = 261.6 BRG = 163 X = 2197.6 Y = 1618.2 CRS = 163 SPD = 0
RANGE TO CONTACT = 0.0 ETA = 0.0

AREA SEARCH

VF 1

R = 190.4 BRG = 40 X = 2241.9 Y = 2013.8 CRS = 90 SPD = 1
RANGE TO CONTACT = 0.0 ETA = 0.0

MOVING STATION

VF 2

R = 191.6 BRG = 21 X = 2308.6 Y = 1398.1 CRS = 90 SPD = 1
RANGE TO CONTACT = 0.0 ETA = 0.0

MOVING STATION

VF 3

R = 177.7 BRG = 117 X = 2277.9 Y = 1737.7 CRS = 90 SPD = 1
RANGE TO CONTACT = 0.0 ETA = 0.0

MOVING STATION

Fig. 5 Status Display

Legend: R = Range from carrier
BRG = Bearing from carrier
CRS = Course of unit
SPD = Speed of unit

DETECTION DISPLAY

The detection display presents a list of all current contact gains and losses by Blue forces. It consists of Blue-unit type and number, gain or loss, contact type and number, range of contact, range and bearing of contact from carrier, course and speed of contact, and number of bombers per raid. The display is used in examining the overall strategy used at any particular time during the operation of the simulation.

DETECTION REPORT

CURRENT TIME = 2.00
VS 2 G AIR 2 #R = 1 R = 198.1 RC = 79.9 BC = 45 C = 28 S = 400.00
VS 2 G AIR 8 BR = 120
COMMUNICATION JAMMER
VS 2 G AIR 10 BR = 109
VS 3 G AIR 1 BR = 272
VS 3 G AIR 2 #R = 1 R = 213.4 RC = 79.9 BC = 45 C = 26 S = 400.00
VS 3 G AIR 8 BR = 43
COMMUNICATION JAMMER
VS 3 G AIR 10 BR = 46
VS 4 G AIR 1 BR = 342
VF 2 G AIR 1 BR = 217
VF 3 G AIR 1 BR = 5

Fig. 6 Detection Display

Legend: G or L = Gain or loss

R = Range of detecting unit from contact
RC = Range of contact from carrier
BC = Bearing of contact from carrier
C = Course of contact
S = Speed of contact
#R = Number of aircraft in raid

SMALL-SCALE DISPLAY

The small-scale display is a pictorial presentation, for any desired scale, of all active Blue units and their locations relative to the carrier. In addition, all Red contacts either appear as bearing lines or are designated by an "R" or an "M" at the location of the contact. The display gives a pictorial view of the current tactical situation and is used to send Blue units to particular contacts or positions.

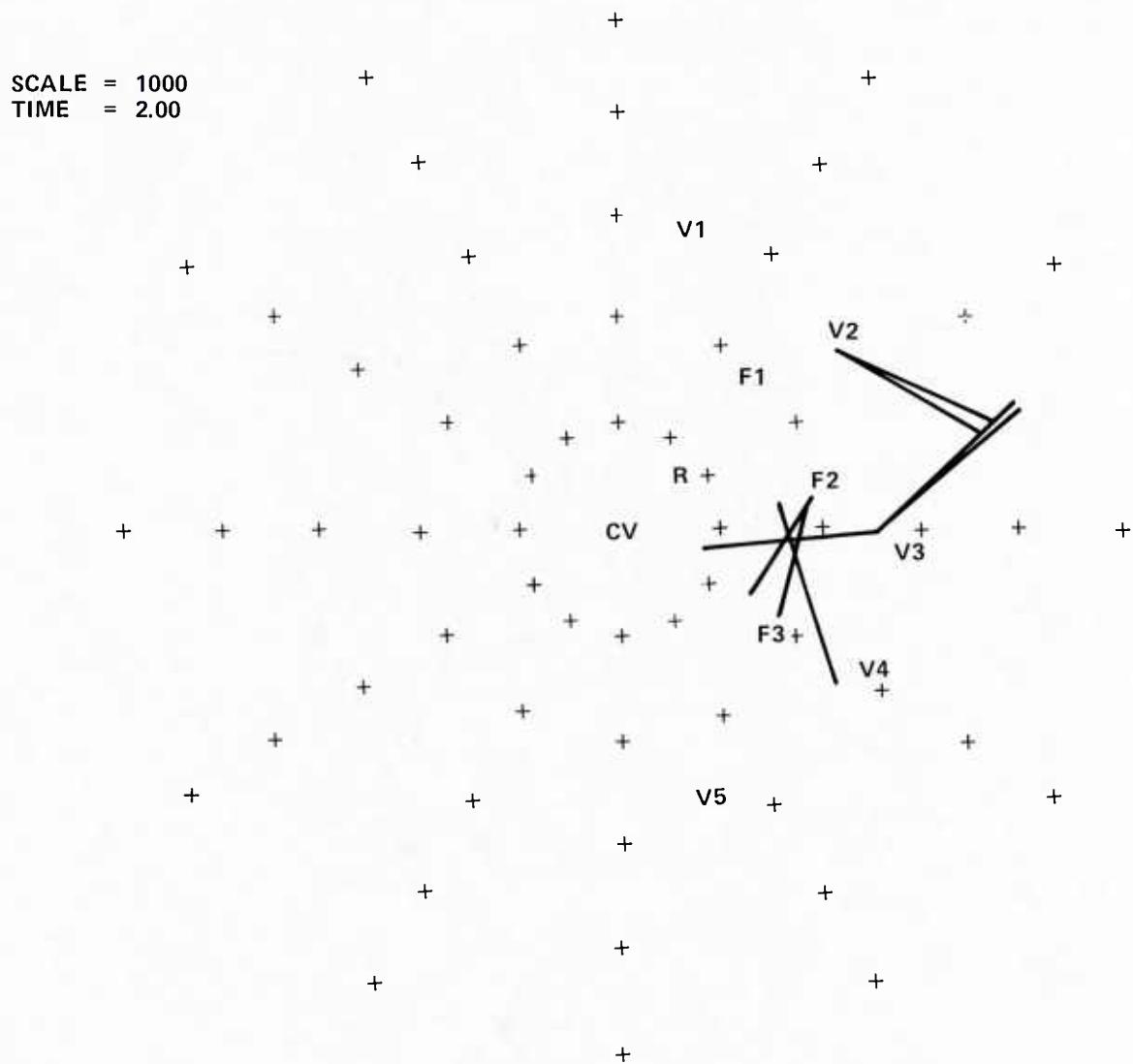


Fig. 7 Small-Scale Display

AREA ENLARGEMENT DISPLAY

The area enlargement display allows the analyst to magnify any part of the playing area in order to diminish the amount of congestion on the screen (given many interactions) and to provide greater accuracy when units are sent to positions on the display.

SCALE = 317
TIME = 2.00 +

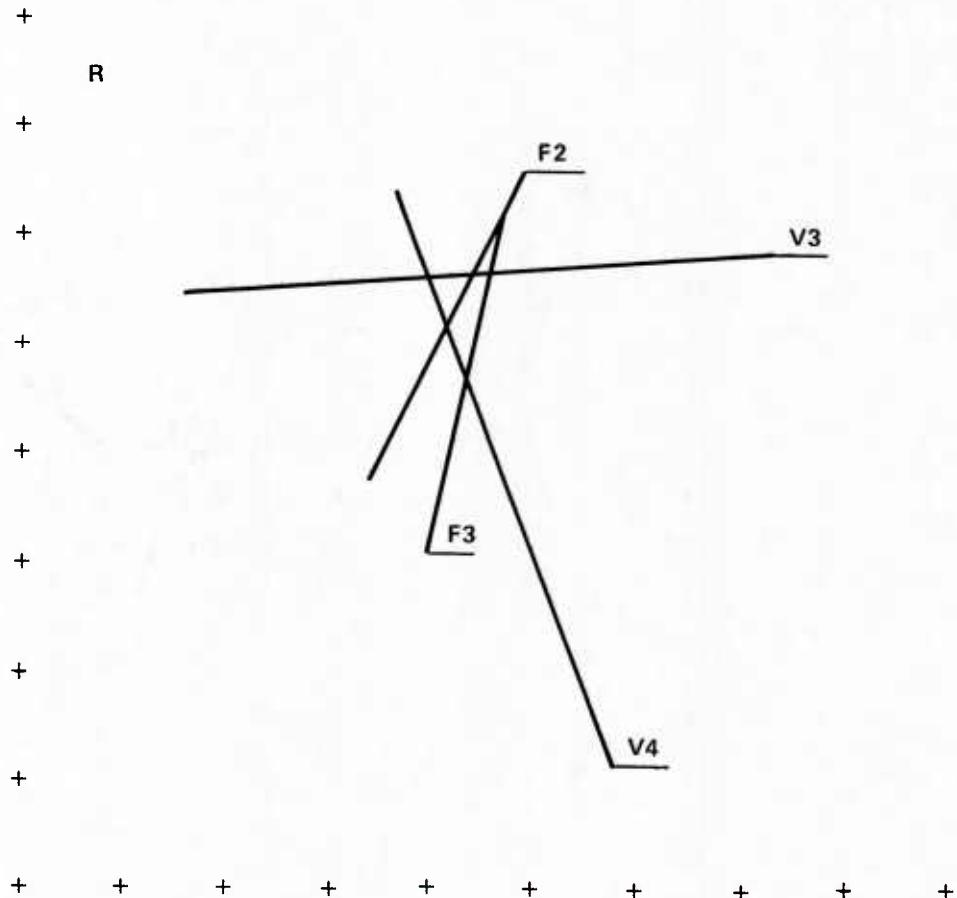


Fig. 8 Area Enlargement Display

NAVIGATION DISPLAY

The navigation display gives information on the current task-force position, location and range of the mission point, and course information for arriving at the mission point.

CURRENT TIME = 2.99
XMISSION = 2818.9 YMISSION = 2950.4
RANGE TO MISSION POINT = 1287.5
BEARING TO MISSION POINT = 33
ETA = 287.52

NAVIGATION REPORT

Fig. 9 Navigation Display

BLUE ATTACK DISPLAY

The Blue attack display allows the analyst to assign Blue units to attack Red units and/or their weapons (i.e., missiles, etc.).

BLUE COUNTER ATTACK 1
CURRENT TIME IN HOURS = 3.92
ENTER UNIT TYPE UNIT NO. RED UNIT TYPE RED UNIT NO.
: 3 1 5 2
: 3 2 5 7
: 3 3 5 10
: 3 6 5 7
: 3 7 5 4

Fig. 10 Blue Attack Display

BATTLE REPORT DISPLAY

The battle report contains information on autonomous interceptor attacks and can be displayed by the analyst provided communication links have been restored. The display has only current battle information.

BATTLE REPORT			TIME = 3.92
3 1 FIRES	2 PHOENIX, 3 SPARROW AND	2 SIDEWINDER AT	5 2
	KILLS 1 AIRCRAFT AND	0 ASM	
3 2 FIRES	3 PHOENIX, 3 SPARROW AND	2 SIDEWINDER AT	5 7
	KILLS 0 AIRCRAFT AND	2 ASM	
3 3 FIRES	3 PHOENIX, 3 SPARROW AND	2 SIDEWINDER AT	5 10
	KILLS 0 AIRCRAFT AND	0 ASM	
3 6 FIRES	3 PHOENIX, 3 SPARROW AND	2 SIDEWINDER AT	5 7
	KILLS 0 AIRCRAFT AND	2 ASM	
3 7 FIRES	0 PHOENIX, 0 SPARROW AND	8 SIDEWINDER AT	5 4
	KILLS 0 AIRCRAFT AND	0 ASM	

Fig. 11 Battle Report

DAMAGE DISPLAY

The damage display is presented after each battle. It indicates all game units, the number of hits received, and whether the units are alive or killed.

DAMAGE REPORT 1			
CURRENT TIME IN HOURS = 3.92			
UNIT	TYPE	UNIT NO.	HITS
5		1	
5		2	
5		3	
5		4	
5		5	
5		6	
5		7	
5		8	
5		9	
5		10	

Fig. 12 Damage Display

Legend: A = Unit alive
K = Unit killed

BATTLE SUMMARY DISPLAY

The battle summary is automatically displayed at the end of a game. It summarizes information on all battles that have occurred during the game.

BATTLE SUMMARY

TOTAL RED ENGAGEMENT

ASM BOMBER AND RECON	=	21
RADAR JAMMER	=	4
COMM. JAMMER	=	3
NO. OF ASM	=	42

TOTAL RED SURVIVAL

ASM BOMBER AND RECON	=	20
RADAR JAMMER	=	0
COMM. JAMMER	=	0
NO. OF ASM	=	36

4. OPERATING INSTRUCTIONS

(For the reader's convenience, the general flowcharts and key identification (Figs. 14, 15, and 16), which pertain to the following discussions, have been placed at the end of this chapter, on pages 33, 34, and 35, respectively.)

LOGON PROCEDURES

1. Place terminal in ASCII mode.
2. LOGON [user identification] (return).
3. EXEC [command procedure name] (return).
4. Set appropriate line speed for terminal. Normal operation is 1200 baud (1200 bytes/s) (return).
5. Select geographic area for game.

0 = Atlantic
1 = Mediterranean
2 = Indian
3 = Pacific

6. Normal start = 0 restart = 1

Note: Restart is used when previous game is to continue from where last interrupted (return).

7. Scenario and run number.

Enter (SNUM, RUNN) (return).

8. Conventional = 0 or nuclear = 1 (return).

Note: This procedure determines the type of weapons used in attack.

OPERATOR CONTROL

Appropriate map display appears. Carrier position appears as an asterisk. Select carrier scenario [course and speed] for input large delta time (LDT). Colon appears for each course and speed selection desired at each LDT.

Sample: 60. (return) [course in degrees]
20. (return) [speed in knots]
90. (return) [course]
20. (return) [speed]
.
.
.
etc. etc. etc.

Carrier track is drawn from initial position to position at maximum game time (TMAX).

[Crosshairs appear.]

Depress R key.

Small-scale display appears with carrier position (game reference) at the center. At this time the analyst, if he desires, can send aircraft to appropriate positions relative to the carrier. Game time is zero hours.

KEYBOARD SELECTIONS (see Fig. 16 on page 37)

Depress

A key - Select firing doctrine during communication jamming (i.e., hierarchy of firing at types of contacts).

1 = radar jammer
2 = communications jammer
3 = bomber

Colon appears. Enter selection.

Sample: 2, 1, 3 (return)

Shoot first at communications jammer, then, radar jammer and, finally, bomber. (If no selection is made random firing is assumed.)

B key - User attack option (see attack instructions). The user may start his attack at any time.

C key - Contact report is displayed.

D key - Update all units.

E key -- Unit tactical range can be changed. Colon appears.
Enter unit type, unit number, and new tactical
range in nmi.

Sample: 5, 1, 50 (return)

F key -- Battle report displays current interceptor-weapon
inventories and target dispositions.

G key -- Send unit. Colon appears. Enter UT, UN, S, DTY,
DNU, P, VAC, NS (return). [Crosshairs appear.]
Position crosshairs where unit is to be sent.
Depress P key: T will appear on the display at
that position. [Crosshairs appear.] Send another
unit or make copy of display.

Where:

UT -- Unit type to be sent;

UN -- Unit number of type to be sent;

S -- Where unit is being sent from:

S = 0, unit sent from carrier,

S < 0, unit sent from current position;

DTY -- Target type unit is being sent to;

DNU -- Target number of target type unit is
being sent to;

P -- Mission designation:

P = 0, area search,

P < 0, moving station,

P > 0, on contact (i.e., P = 2. Unit is
being sent to target contact
number 2),

P = 80, aircraft returned to carrier;

VAC -- Speed of the unit being sent;

NS -- New or old aircraft being sent:

NS = 0, new aircraft being sent,

NS > 0, aircraft has already been sent on
a mission and is now being sent
on a new mission.

Note 1: Always set NS = 0 for all units except aircraft.

Note 2: For returning aircraft to carrier: S = -1, DTY = 1,
DNU = 1, P = 80, NS \geq 1.

Note 3: For sending an aircraft that had previously been returned to carrier: $S = 1$, $NS \geq 1$.

Note 4: For unit sent on area search or moving station: $DTY = 0$, $DNU = 0$.

Note 5: Do not confuse target unit number with contact number.

H key — Course of a unit can be changed. Colon appears.
Enter unit type and unit number of unit to be changed.

Sample: 3, 2 (return) [VF A/C #2]

Colon appears. Enter new course [decimal].

Sample: 240. (return)

I key — Status display appears.

J key — Map display appears with current carrier position.

K key — Navigation display appears.

L key — Unit update time can be changed. Colon appears.
Enter DELTA T [decimal].

Sample: .5 (return)

M key — Blue units without tracks and Red units currently detected by Blue are displayed. (This display is used to send aircraft on mission.)

N key — Detection DELTA T can be changed. Colon appears.
Enter DELTA T [decimal].

Sample: .2 (return)

O key — Area enlargement. Place crosshairs on lower left position of area to be enlarged. Depress O key. Move crosshairs to lower right position of area to be enlarged. Depress any key. Enlarged areas will be displayed.

P key — Interceptor firing switch:

0 → Don't shoot at target(s),
1 → Shoot at target(s) when within firing range.

Q key — Blue units with tracks and Red units currently detected by Blue are displayed.

S key — Speed of a unit can be changed (same as for the H key).

T key — Carrier course can be changed. Colon appears.
Enter new course (return).

V key — Carrier speed can be changed. Colon appears.

W key — Display scale can be changed. Colon appears.
Enter scale [decimal].

Sample: 50. (return)

Y key — End game (return).

U key — Rerarm interceptor. UN, Phoenix, Sparrow, Sidewinder. Colon appears. Enter interceptor number to be rearmed, number of Phoenix missiles, number of Sparrow missiles, and number of Sidewinder missiles (return).

ATTACK INSTRUCTIONS

The analyst has the option to attack Red at any time during the running of the game by depressing the B key.

1. Depress the B key: the buzzer sounds twice, and the detection-report display appears.
2. Depress the R key: the small-scale display appears with all game unit positions and headings. Crosshairs appear.
3. Depress the B key: the attack selection display appears.
 - a. Crosshairs appear.
 - b. Depress the A key.
 - c. Colon appears.
 - d. Enter Blue-unit type, Blue-unit number, Red-unit type to be attacked, and Red-unit number.
 - e. Crosshairs appear. If further Blue attacks are to continue, go to step 3b and repeat.
 - f. If Blue attack selections are complete, make a copy.

4. Depress the Z key: damage display appears.
5. If the attack or game is to continue depress the K key: continue playing the game.
6. If there is to be only that particular attack, after the damage display appears, depress the R key: the map display appears and crosshairs appear. Depress the R key: final status display appears and crosshairs appear. Depress any key except the R key and the game will end.

Note 1: Anytime the status or detection report display is filled, a buzzer sounds and crosshairs appear. At this point make a copy of the display and then depress the R key. This causes the reports to be continued from where they left off, until the display is again filled. At that time repeat the above procedure until all units are displayed.

Note 2: When initial contact is made by any Blue unit or an attack is initiated, the task force commander (user) is alerted by the sound of a buzzer. This allows the user to take appropriate action at that time.

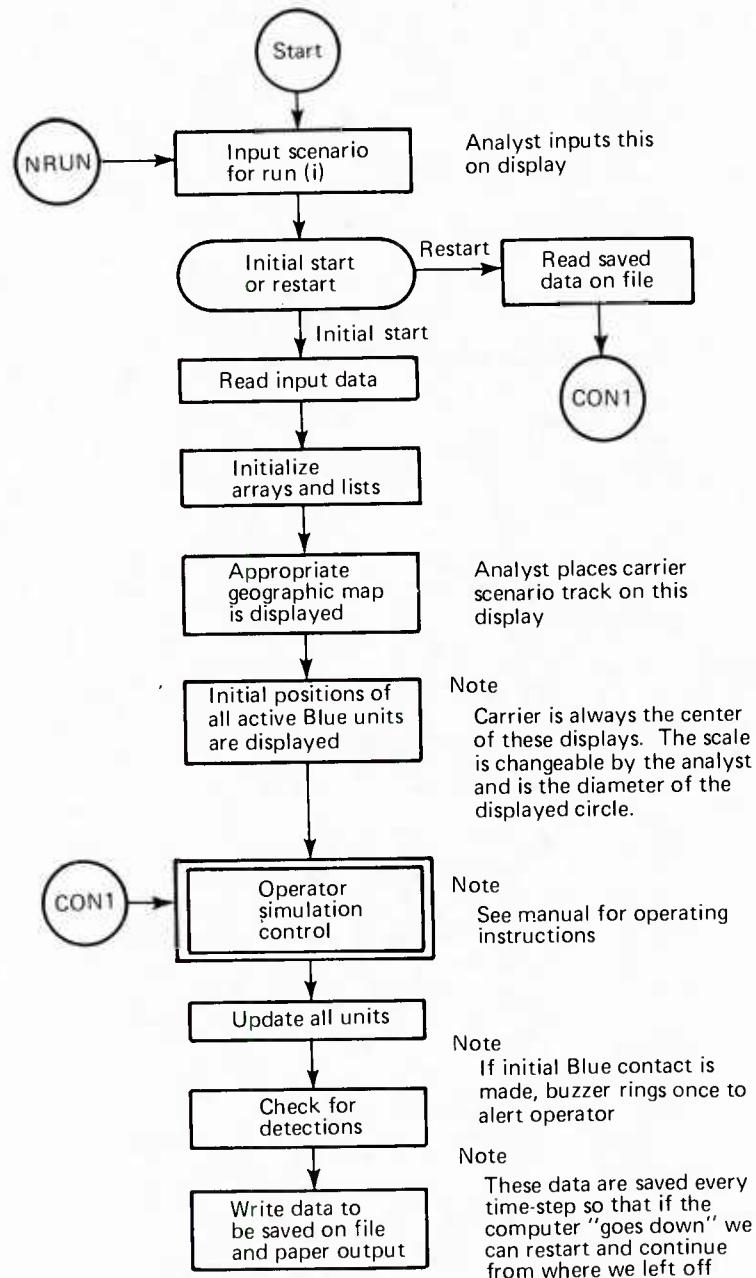


Fig. 14 Program Sequence Chart, Part 1

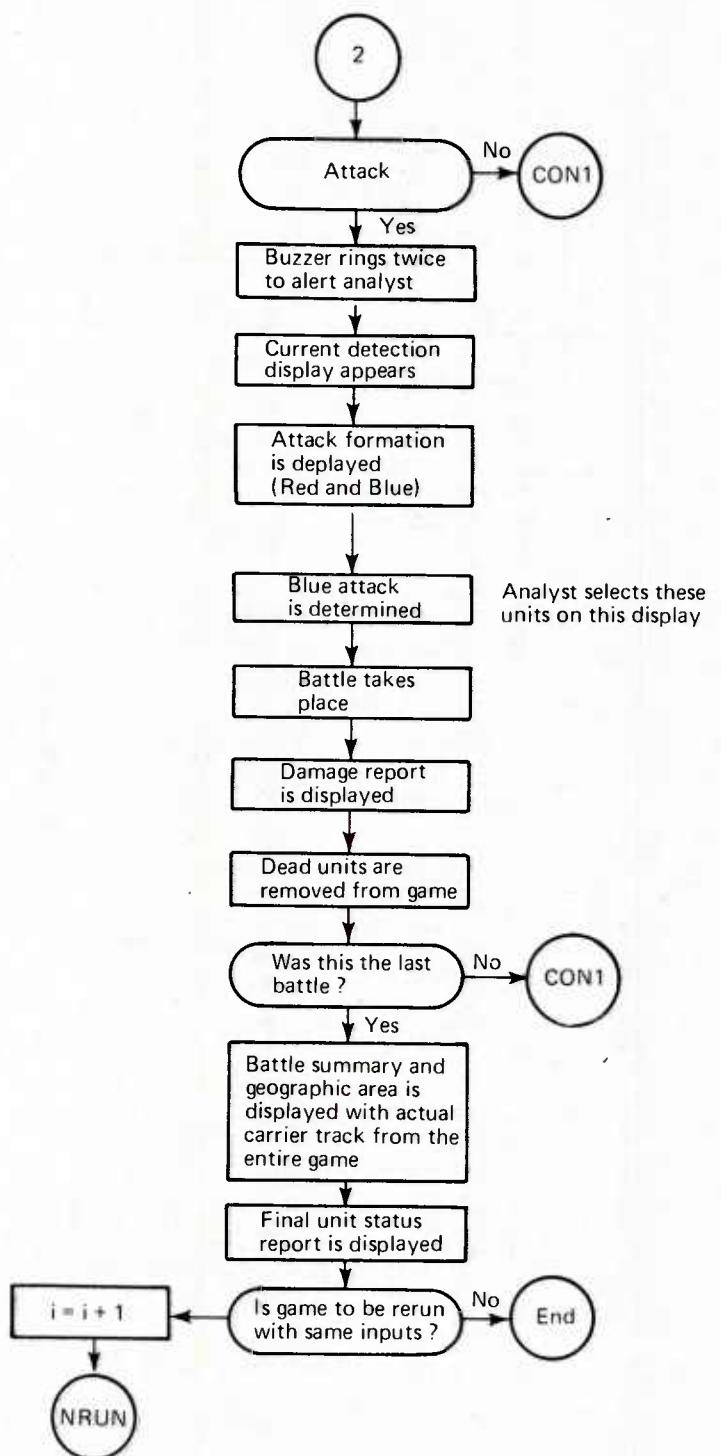
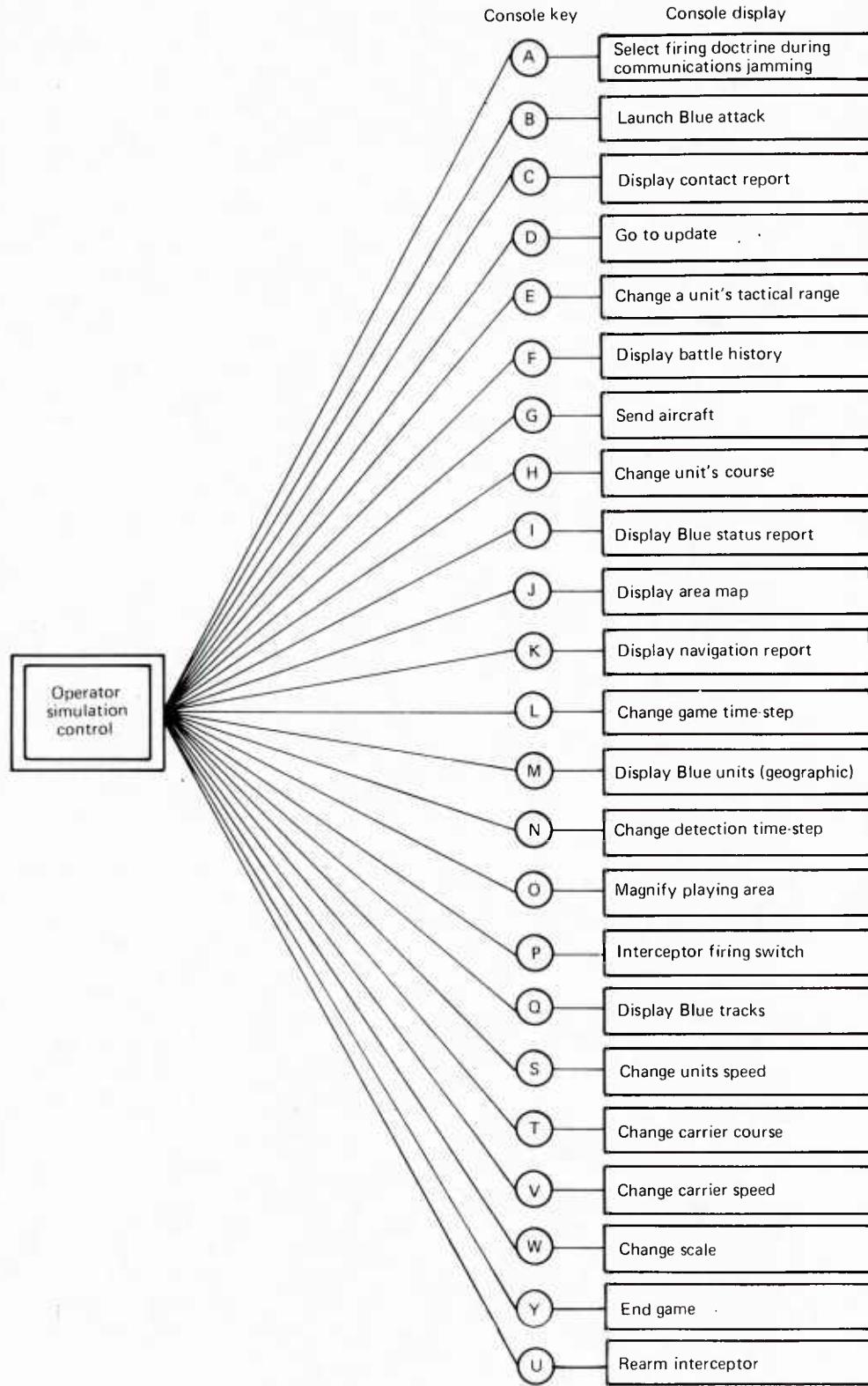


Fig. 15 Program Sequence Chart, Part 2



5. UNIT INTERACTIONS

DETECTIONS

A unit makes a detection when an enemy is within its detection range. Detection ranges are inputs and must be precalculated outside the model, based on either a clear or jammed environment; they are a function of aircraft type (e.g., an interceptor, AEW, CAP, etc.) and type of raid (e.g., high raid or low raid). It is assumed that each aircraft uses its optimum detection capability based on its assignment.

Each interceptor has an input detection range in a clear environment (radar "fix") or jammed environment (radar "strobe"), an infrared detection range for a jammed environment, and a "burn-through" range that is analogous to a visual or radar fix. AEW and CAP aircraft have clear or jammed environment input ranges that reflect radar fixes or strobes.

JAMMING

Radar Jamming

In order to simplify the jamming problem, the jammed environment is partitioned into jamming areas. A jamming group is defined as consisting of a number of radar jammers and all Red aircraft masked by the radar jammers. The ranges of the radar jammers determine the bounds of the area jammed for each jamming group. Each jamming group is mutually disjoint. After a VF/AEW detects a radar jammer, an errored bearing line appears on the small-scale display. The length of the bearing line is equal to the maximum length of the VF/AEW detection range. If a VF burns through a jamming group, all aircraft in the jamming group appear on the small-scale display. Bearing lines will remain on the screen for all AEW and for any VF outside the burn-through range. If all radar jammers are killed in a particular jamming group, then the jammed area becomes clear.

Communication Jamming

Communication jamming can occur inside or outside the horizon of the carrier.

Outside the Horizon. If there are communication jammers outside the horizon of the carrier, there must be an input of at least one radar jammer because communication jamming outside the horizon of the carrier is initiated when the first radar jammer is

detected. At this time all communication jammers with TAC = 2 begin jamming (TAC = 2 is an input). If at any time a communication jammer enters the horizon of the carrier, its TAC will be set equal to 3 and it will become a communication jammer inside the carrier's horizon. During the time interval that the communication links to the carrier are broken, all detected Red aircraft disappear from the screen. During the communication blackout, autonomous battles can occur as an option of the analyst. Results of the battles can only be known after communication is restored. Communication links are restored either permanently after all communication jammers are killed or temporarily for a specified time interval (a function of the number of communication jammers with TAC = 2). The lengths of the communication jamming cycles are recalculated after every battle and whenever a communication jammer with TAC = 2 enters the carrier's horizon. An errored bearing line appears on the small-scale display during the time that the communication links are restored if a VF/AEW detects a communication jammer with TAC = 2 and the communication jammer is masked by a radar jammer. The length of the bearing line is equal to the maximum length of the VF/AEW detection range. The detection report identifies whether the detected aircraft is a communication jammer or a radar jammer. If a VF burns through, the bearing line will be replaced by a letter M indicating the location of the detected communication jammer. If a VF/AEW detects a communication jammer not masked by a radar jammer, then the letter M will appear on the display indicating its location.

Inside the Horizon. Communication jamming inside the horizon of the carrier initially occurs when the first communication jammer penetrates the horizon of the carrier. Similar to the preceding case there is an interval in which communication links to the carrier are broken and an interval in which the communication links are restored.

The lengths of the communication jamming cycles are recalculated after every battle and whenever a communication jammer enters or leaves the horizon of the carrier. If a VF/AEW detects a communication jammer with TAC = 3 outside the horizon of the carrier, an R appears indicating the location of the contact. At this time the analyst does not know whether the aircraft is a communication jammer (which should be the case since a communication jammer with TAC = 3 only jams inside the carrier's horizon).

If a VF/AEW detects a communication jammer with TAC = 3 inside the carrier's horizon, the method for showing detection is the same as the preceding case.

Attacks

Blue interceptor aircraft can either track or attack Red air raids at the discretion of the analyst. In addition, the analyst has the option of selecting an interceptor firing doctrine (see A and P keys, under operating instructions).

The program allows for analyst-controlled interceptor attacks and autonomous interceptor attacks when communications are jammed. In the presence of communication jamming, central direction is not possible; the interceptor must act autonomously. Provisions have been made for selective firings against types of targets if existing data were to permit discrimination of vehicle types (e.g., SOJ aircraft, ASM aircraft, communications jamming aircraft). Otherwise, a random firing doctrine is assumed.

During autonomous interceptor attacks the interceptors maintain their predetermined courses and speeds. Because operator assignments are not permitted during communications jamming, care must be taken to reassign those interceptors that have either fired all their weapons, or killed or lost all their targets when communications have been restored.

In order to launch missiles, the interceptors must be within their appropriate weapon firing ranges. Interceptors are equipped with Phoenix/Sidewinder/Sparrow missiles, either pure or mixed loads, as desired.

Red aircraft are equipped with ASM missiles. The number of missiles for each Red air raid is selected by input. Red aircraft launch their missiles when they come within their input tactical ranges. At this point, Blue aircraft attempt to intercept any incoming missiles within their range.

Battle reports that contain information on autonomous interceptor attacks can be displayed by the analyst, provided communication links have been restored. At the end of a game, a battle summary is automatically displayed. The summary contains information on all battles that have taken place during a game.

6. INPUTS

Card 1

WORD 1	NBVS	— Number of Blue VS aircraft (integer)
WORD 2	NBVF	— Number of Blue VF aircraft (integer)
WORD 3	RMAXA	— Maximum detection range for Blue aircraft (nmi)
WORD 4	TMAX	— Destination time for carrier (hours)
WORD 5	LSCAL	— Scale for map (nmi)
WORD 6	SCAL	— Scale for carrier disposition (nmi)
WORD 7	LDT	— Time interval for initial carrier scenario (hours)
WORD 8	UDT	— Game update time (hours)
WORD 9	TDET	— Time interval for computing detections (hours)
WORD 10	BCRS	— Initial course for carrier (degrees)
WORD 11	VS	— Initial speed for carrier (kt)

Card 2

WORD 1	NRAU	— Number of Red air raids (integer)
WORD 2	NDUMY	— Number of dummy units (integer) (number of points required for Red air plan; see Fig. 2)

Card 3

WORD 1	NJG	— Number of jamming groups (integer)
WORD 2	NCJ	— Number of communication jammers of type TAC=2 (integer)
WORD 3	CJRANG	— Carrier's horizon range (nmi) (see Card 33)

Card 4

WORD 1		— Initial X-coordinate of carrier (nmi)
WORD 2		— Initial Y-coordinate of carrier (nmi)

Card 5

WORD 1

WORD 2

.

.

.

WORD NRAU

} — Red air raid ranges relative to the carrier
(nmi)

Card 6

WORD 1

WORD 2

.

.

.

WORD NRAU

} — Red air raid bearings relative to the carrier
(degrees)

Card 7

WORD 1 NRLR — Number of Red low raids (integer)

WORD 2 RDETAAL — Blue detection range for VS versus low raid
(nmi)

WORD 3 RDETAAH — Blue detection range for VS versus high raid
(nmi)

Card 8

WORD 1

WORD 2

.

.

WORD NRAU

} RDET — Air raid detection ranges (nmi)

Card 9

WORD 1

WORD 2

.

.

WORD NRAU

} RAIDT — Indicates high or low raid for each air
raid (0 → low, 1 → high)

Card 10

WORD 1

WORD 2

.

.

.

WORD NRAU

} RTAC - Tactical ranges for each air raid (nmi)

Card 11

WORD 1

WORD 2

.

.

.

WORD NRAU

} V - Speeds for each air raid (kt)

Card 12

WORD 1 RMAXRA - Range set to inhibit Red aircraft attack (nmi)

Card 13

WORD 1 NRCON - Number of Red reconnaissance aircraft (integer)
(these do not attack)

WORD 2 RASPD - Red aircraft closing speed (kt) (same for all
Red aircraft)

WORD 3 TMAX2 - Red aircraft closing time (hours) (same for
all Red aircraft)

Card 14

WORD 1 PKPHNX - Kill probability of Phoenix for low raid

WORD 2 PKPHNX - Kill probability of Phoenix for high raid

Card 15

WORD 1 PKSPAR - Kill probability of Sparrow for low raid

WORD 2 PKSPAR - Kill probability of Sparrow for high raid

Card 16

WORD 1 PKSW - Kill probability of Sidewinder for low raid

WORD 2 PKSW - Kill probability of Sidewinder for high raid

Card 17

WORD 1
WORD 2 NSS
.
.
.
WORD NRAU

} — Number of missiles for each Red air raid
(integer) (# missiles/A/C * NAF = NSS; see
Card 18)

Card 18

WORD 1
WORD 2
.
.
.
WORD NRAU

} NAF — Number of Red aircraft in each raid

Card 19

WORD 1
WORD 2
.
.
.
WORD NRAU

} PKSL — Probability of successful launch of an
ASM for each air raid

Card 20

WORD 1 PHTIM — Run-in time of a Phoenix (hours)
WORD 2 SPTIM — Run-in time of a Sparrow (hours)
WORD 3 SWTIM — Run-in time of a Sidewinder (hours)

Card 21

WORD 1 RGPH — Maximum firing range for Phoenix (nmi)
WORD 2 RGSP — Maximum firing range for Sparrow (nmi)
WORD 3 RGSW — Maximum firing range for Sidewinder (nmi)

Card 22

WORD 1
WORD 2
.
.
WORD NBVF } NMMPH — Number of Phoenix missiles per VF (integer)

Card 23

WORD 1
WORD 2
.
.
WORD NBVF } NMSP — Number of Sparrow missiles per VF (integer)

Card 24

WORD 1
WORD 2
.
.
WORD NBVF } NMSW — Number of Sidewinder missiles per VF (integer)

Card 25

WORD 1
WORD 2
.
.
WORD NBVF } RTAC — Firing ranges for Blue interceptors (nmi)

Card 26

WORD 1
WORD 2
.
.
WORD NRAU } DPI — End of first leg along track for each Red air raid (integer) (a function of the range and bearing at end of each leg, Cards 30 31)

Card 27

WORD 1
WORD 2
.
.
.
WORD NRAU } DP2 - End of second leg along track for each Red air raid (integer) (a function of the range and bearing at end of each leg, Cards 30 and 31)

Card 28

WORD 1
WORD 2
.
.
.
WORD NRAU } VT1 - Velocity along first leg of track for each Red air raid (kt)

Card 29

WORD 1
WORD 2
.
.
WORD NRAU } VT2 - Velocity along second leg of track for each Red air raid (kt)

Card 30

WORD 1
WORD 2
.
.
WORD NDUMY } - Initial range relative to the carrier from the end of each leg of the track for each Red air raid (nmi) (see Fig. 2)

Card 31

WORD 1
WORD 2
.
.
WORD NDUMY } - Initial bearing relative to the carrier from the end of each leg of the track for each Red air raid (degrees) (see Fig. 2)

Card 32	
WORD 1	
WORD 2	
.	
.	
WORD NRAU	
	{
	NNG — Indicates type of environment for each Red air raid
	0 → Red air raid in a clear environment
	1 → Red air raid in a jammed environment
Card 33	
WORD 1	
WORD 2	
.	
.	
WORD NRAU	
	{
	TAC — Indicates type of aircraft
	0 → Recon/bomber
	1 → Radar jammer
	2 → Communication jammer outside horizon of carrier
	3 → Communication jammer inside horizon of carrier*
Card 33.1	
WORD 1	
WORD 2	
.	
.	
WORD NRAU	
	{
	1st jamming group
	UJG — Identifies the radar jammers in each jamming group and the air raids masked by the jammers
Card 33.NJG	
WORD 1	
WORD 2	
.	
.	
WORD NRAU	
	{
	Last jamming group
	0 → Air raid masked by radar jammer
	1 → Radar jammer
	2 → Air raid not masked by radar jammer
Card 34	
WORD 1	
WORD 2	
.	
.	
WORD NJG	
	{
	NJG — Number of radar jammers in each jamming group (integer)

*If TAC ≠ 3 for all Red air raids then set CJRANG = 0.

Card 35		
WORD 1		
WORD 2		
.		
.		
.		
WORD NBVF		RVF1 - Detection range for each VF in a jammed environment (nmi)
Card 36		
WORD 1		
WORD 2		
.		
.		
.		
WORD NBVF		RVF2 - Infrared detection range for each VF in a jammed environment
Card 37		
WORD 1		
WORD 2		
.		
.		
.		
WORD NBVF		RVF3 - Detection range for each VF in a clear environment
Card 38		
WORD 1		
WORD 2		
.		
.		
WORD NBVF		RVF4 - Burn-through range for each VF (nmi)
Card 39		
WORD 1		
WORD 2		
.		
.		
WORD NBVS		RVS1 - Detection range for each VS in a jammed environment (nmi)

Card 40

WORD 1 SIGMA1 - Bearing error for VF detection in a jammed environment (degrees)
WORD 2 SIGMA2 - Bearing error for VF infrared detection in a jammed environment (degrees)
WORD 3 SIGMA3 - Bearing error for VS detection in a jammed environment (degrees)

Card 41

WORD 1
WORD 2
:
:
WORD NCJ } DT0N - Time interval that communication is disrupted when communication jamming is outside the horizon of the carrier (a function of the number of communication jammers) (hours)

Card 42

WORD 1
WORD 2
:
:
WORD NCJ } DTOFF - Time interval that communication links remain open despite communication jamming outside the horizon of the carrier (a function of the number of communication jammers) (hours)

Card 43

WORD 1
WORD 2
:
:
WORD NRAU } DT0N1 - Time interval that communication is disrupted when communication jamming is inside the horizon of the carrier (a function of the number of communication jammers)

Card 44

WORD 1
WORD 2
:
:
WORD NRAU } DTOFF1 - Time interval that communication links remain open despite communication jamming inside the horizon of the carrier (a function of the number of communication jammers) (hours)

Note: Procedures are available to handle classified data.

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